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Social capital and CO_2 emission—output relations: A panel analysis

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ABSTRACT

The present paper examines the mitigating effect of social capital on the environmental Kuznets curve (EKC) for CO_2 emissions using a panel data of 69 developed and developing countries. Adopting generalised method of moments (GMM) estimators, the paper finds evidence substantiating the presence of EKC. Moreover, the evidence suggests that the pollution costs of economic development tend to be lower in countries with higher social capital reservoir. Surprisingly, there is also evidence to indicate that the income threshold point beyond which CO_2 emissions decline is higher in countries with higher social capital. These results are robust to addition of alternative controlled variables in the EKC specification. Thus, in addition to policy focus on investments in environmentally friendly technology and on the use of renewable energy, investments in social capital can also mitigate the pollution effects of economic progress.

Contents

1. Introduction

The relations between pollutant emissions and economic development have captured much attention over the past 2 decades. Arguably, as posited by the environmental Kuznets curve (EKC), the environmental problem arising from greenhouse gas (GHG) emissions and economic development form an inverse U-shaped relation. At the early stage of development, economic growth tends to exacerbate the GHG emissions and consequently contributes to global warming and climate changes. Then, when economic development passes a threshold point, it serves as a solution to the environmental problem as GHG emissions tend to decline. This postulated emission–economic growth relation has received extensive empirical treatments to verify its presence as well as to determine the income threshold point, especially since the seminal study by Grossman and Krueger [1]. The extensive surveys of these studies are provided by Dinda [2] and Stern [3].

The EKC suggests leaning against economic development to later alleviate the environmental problems, although it entails inevitable sacrifice of the environment at the early stage of development. This suggestion has a potential danger, however. As argued by Song et al. [4], there can be a point of irreversible environmental damages if the environment is used indiscriminately to boost economic growth. Once the point is reached, there would be no income threshold point as the increase in income will add further damages to the environment. If this is true, the natural enquiry to the problem of environment is: can the EKC be flattened or shifted downwards?

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In the literature, increasing but still limited number of studies has emerged in recent years to address this enquiry. The focus of these studies has been on the potential roles of policies and institutional quality in the abatement of environmental problems. According to Panayatou [5]:

> The improvement of the environment with income growth, however, is not automatic but depends on policies and *institutions*… Whether environmental quality improvements (or reduced degradation) materialize or not, when and how depends critically on government policies, *social institutions* and the completeness and functioning of markets.Panayotou [5], p. 468

Based on this argument, he analyses the EKC for SO_2 concentrations for an unbalanced panel of 30 developed and developing countries and incorporates an indicator of institutional quality suggested by Knack and Keefer [6], i.e. the respect/enforcement of contracts, in the analysis. He finds supportive evidence that the quality of policies and institutions does flatten the EKC in that, with better institutional quality, the environmental costs of economic growth are lower at the early stage of development and the speed of environmental improvement is faster as income increases.

Bhattarai and Hammig [7], Culas [8] and Leitão [9] are among recent studies on the link between institutions and the environment–income relations. In their analysis, Bhattarai and Hammig [7] combine political rights and civil liberty indices as a measure of institution and evaluate whether it has a bearing on deforestation in Latin America, Africa and Asia. They find evidence that the institutional quality significantly shifts the EKC downwards in Latin America and Africa. Culas [8] reassesses the EKC for deforestation for 14 tropical developing countries from Latin America, Africa and Asia for the period of 1972–1994. He uses the institutional measures suggested by Knack and Keefer [6] and adopted by Panayotou [5] in the analysis. Applying standard panel estimation methods (pool regression, fixed effect panel and random effect panel), he reaffirms the presence of the EKC for deforestation for Latin America and the downward shift in the EKC as institutional quality increases. More recently, Leitão [9] focuses on the EKC turning point for sulphur and its relation to corruption index provided by the International Country Risk Guide (ICRG) for a panel of 94 countries. Using panel fixed and random effects models and the inverted U-shaped specification of Bradford et al. [10], she documents a positive relation between a country's corruption level and the income threshold point beyond which sulphur emissions decline.

In the present paper, we make further attempt to contribute to this line of enquiry. In the analysis, we focus on CO_2 emissions, which are viewed to be the most important global pollutant contributing about 72% of the global warming effects [11]. Complementing the above studies, we bring into the analysis the roles played by social capital, an aspect that has not been much emphasised. The focus on whether social is a significant factor in emission–income patterns has relevance for at least two reasons. First, like formal institutions, such informal institutional quality as trust and networks not only defines (informal) rules or constraints for economic courses of actions and activities but also serve as self-enforcement mechanisms. The social capital reservoir can thus be central in the pollution problem, as eloquently stressed by Illingworth [12] in her analysis of ethics and social capital. Accordingly, this aspect of institutions and its relations to the EKC deserve a specific attention. And second, since the environmental problems emerge at the early stage of economic development, they are principally the problems of poor and developing countries. In these countries, formal institutions are generally weak. Accordingly, there is a need to look at whether social capital is a factor that can influence the EKC.[1]

The analysis relies on the generalised method of moments (GMM) estimation approach, the merits of which to be detailed later, to a panel of 69 countries and adopts the recently constructed measure of social capital by Lee et al. [15] using data sample from more recent periods. The rest of the paper is structured as follows. In the next section, we detail the empirical framework and data. Then, Section 3 discusses estimation results. Finally, Section 4 concludes with a summary of the main findings and some concluding remarks.

2. Empirical approach and data

2.1. Model specification

In the analysis, we adopt a standard quadratic relation between CO_2 emissions and income and incorporate energy consumption as a controlled variable [16–19], written as

$$\mathrm{LCO}_{2\ it} = \alpha_i + \gamma \mathrm{LCO}_{2\ it-1} + \beta_1 \mathrm{L}GDP_{it} + \beta_2 \mathrm{L}GDP_{it}^2 + \beta_3 \mathrm{L}EC_{it} + \varepsilon_{it} \tag{1}$$

where subscripts i and t refer to country and year respectively, CO_2 is the carbon dioxide emissions per capita, *GDP* is the real GDP per capita, *EC* is the energy consumption per capita, the prefix "L" represents the natural logarithm, α_i is a country-specific effect, γ, β_1, β_2, and β_3 are the slope parameters to be estimated, and ε is the model's error term. We include the lagged dependent variable to account for temporal dependence in CO_2 emissions, which can be justified by gradual changes in the production structure and technology. Accordingly, γ is expected to be positive. β_3 is also expected to be positive since higher energy use tends to emit more carbons given the adopted technology. The focal parameters in the model are β_1 and β_2. The presence of the EKC is verified by β_1 being significantly positive and β_2 significantly negative. Based on (1), the income turning point (in natural logarithm) can be estimated as $-\beta_1/\beta_2$.

Note that Eq. (1) assumes a homogenous pattern of the EKC for all countries. This is very restrictive since the relation between emissions and development is likely to differ across countries [20–22]. To examine our central thesis that social capital can be a potential determining factor of the difference in the emissions–income relations across countries, we extend Eq. (1) by incorporating a measure of social capital interactively with real income and real income squared.[2] Namely,

$$\begin{aligned}\mathrm{LCO}_{2\ it} = {} & \alpha_i + \gamma \mathrm{LCO}_{2\ it-1} + \beta_1 \mathrm{L}GDP_{it} + \beta_2 \mathrm{L}GDP_{it}^2 + \beta_1^*(\mathrm{L}GDP_{it} \times SC_i) \\ & + \beta_2^*(\mathrm{L}GDP_{it}^2 \times SC_i) + \beta_3 \mathrm{L}EC_{it} + \varepsilon_{it}\end{aligned} \tag{2}$$

where SC_i is the measure of social capital of country i. Based on (2), the EKC is supported when $\beta_1 + (\beta_1^* \times SC_i)$ is positive and $\beta_2 + (\beta_2^* \times SC_i)$ is negative and the income turning point is

$$-[\beta_1 + (\beta_1^* \times SC_i)]/2[\beta_2 + (\beta_2^* \times SC_i)] \tag{3}$$

From (2) and (3), the social capital will have significant influence on the shape of the EKC if β_1^* or β_2^* or both are statistically significant. More specifically, the EKC will shift downward as the social capital increases, suggesting lower environmental costs of development, if β_1^* is significantly negative. In addition, the income

[1] In the literature on finance development, various studies have emphasised the importance of informal institutions in countries with weak formal institutions [13,14]. Accordingly, informal institutions like trust and norms could also be relevant for the EKC.

[2] Since our measure of social capital is fixed across the period, it will be perfectly correlated with country-specific effects. Accordingly, we do not include SC independently in the model [23].

turning point is lowered with higher level of social capital if β_2^* is significantly less than 0. However, if β_2^* is positive, whether SC lowers or increases the income turning point depends on the relative size (in absolute term) of β_1^* and β_2^*.

We take Eq. (2) as a baseline specification. While the specification is based on the synthesis between energy–economic growth and pollution–economic development literatures, several other controlled variables have also been considered. Some studies include a measure of trade openness in the EKC analysis [24–27]. In addition, on the basis of the growth model, others have included a measure of fixed capital formation as an additional controlled variable [28–31]. Finally, such population-related variables as population density, labour force or employment and urban population or urbanisation have also been linked to pollution. These include population density [32], employment [28,33], urban population [29,31], and urbanisation [34,35]. Thus, in the present analysis, we add trade openness, fixed capital formation and urbanisation to the baseline specification for robustness check.

2.2. Estimation method

Given the panel nature of our data, we adopt panel estimation techniques to estimate (1) and (2). The standard panel models like the pooled OLS regression model, the fixed-effect panel model and the random-effect panel model are not appropriate due to the presence of country-specific effects and the lagged dependent variable or potential endogeneity of explanatory variables. Even we assume that the error terms are not autocorrelated, the coefficient estimates from such estimators as OLS or least square dummy variable (LSDV) estimators are biased [36]. Arellano and Bond [37] suggest a generalised method of moments (GMM) estimator to tackle the above problems. More specifically, the GMM method wipes out the country-specific effects or any time-invariant country-specific variable by taking the first differences of (1) and (2). Then, to resolve the resulting correlation between lagged dependent variable and disturbance terms after first differencing, Arellano and Bond [37] suggest the use of instrumental variables. Namely, the differenced lagged dependent variables and other endogenous variables can be instrumented with their lags in levels, lagged two or more periods while the exogenous variables can serve as their own instruments. The method is known as the first-difference GMM estimator and it can be either one-step GMM estimator or two-step GMM estimator. The one-step GMM estimator assumes independent error terms and homoskedastic error variances across countries and times. Meanwhile, the second-step GMM estimator uses the residuals of the first-step estimation to construct a consistent variance–covariance matrix when the assumptions of independence and homoscedasticity do not hold.

A main problem with the first-difference GMM estimator, however, is its neglect of potential information in the level relationship and in the relations between the levels and the first differences [38]. Moreover, as noted by Blundell and Bond [39], the level variables are weak instruments for their first differences if they exhibit persistency. Arellano and Bover [40] suggest addressing these problems by estimating the level and first-difference regressions as a system, which is known as a system-GMM estimator. In the estimation, the level regression is instrumented with lagged first-differenced variables while the first-differenced regression instrumented with lagged level variables. As pointed out by Blundell and Bond [39], the system GMM estimator provides an improvement over the first-difference GMM estimator when the dependent variable is highly persistent with the autoregressive term close to unity and the number of time periods is small. In light of these econometric issues, we adopt the two-step system GMM in the analysis. Still, the results from the two-step first-difference GMM are also reported for comparison.

The consistency of the GMM estimator depends on two specification tests, the Sargan over-identifying restrictions and a serial correlation test in the disturbances [37]. The Sargan test is based on the overall validity of the instruments by analysing the sample analogue of the moment conditions used in the estimation process. Failure to reject the null of the Sargan test would imply that the instruments are valid and the model is correctly specified. In terms of the serial correlation test, one should reject the null of the absence of the first order serial correlation (AR1) and not reject the absence of the second order serial correlation (AR2).

2.3. Data

The present analysis makes use of the index of social capital recently developed by Lee et al. [15] for 72 developed and developing countries. In their paper, they extract the principal components from 44 variables encompassing four main components of social capital—social trust, norms, networks and social structure—to construct the social capital index. The information on the 44 variables is mostly from the year 2000 onwards. The index takes the value of 0–10 with the higher value reflecting higher level of social capital and it is scaled to be normally distributed with a mean of 5. Taking a broad array of social capital indicators, Lee et al. [15] have developed a comprehensive measure of social capital across a large number of countries. CO_2 emissions (CO_2) are represented by carbon dioxide emissions measured in metric tons per capita while real GDP per capita (*GDP*) is used as a measure of economic development or level of income. The *GDP* is in constant 2000 US dollar. We utilise the energy use (kg of oil equivalent per capita) as a measure of energy consumption (*EC*). As for the additional controlled variables, we use the ratio of trade (exports plus imports) to GDP for trade openness (*OPEN*), the fixed capital formation to GDP for investment (*INV*), and the percentage of population in urban areas for urbanisation (*URBAN*). Data on CO_2 emissions, real GDP, energy use and other controlled variables are sourced from World Development Indicators.

We employ a panel sample of 69 developed and developing countries over the period 2000–2008 (see Table 1), the end year is dictated by the availability of data on CO_2 emissions. The countries correspond to those in Lee et al. [13]. We drop three countries from their sample due to the unavailability of data on the main variables. Note that, by choosing the beginning year to be 2000, we not only align the analysis with the constructed measure of social capital but also can justify time-invariant nature of social capital since institutions are unlikely to change over the 9-year period. Table 1 presents the list of countries grouped into four quartiles according to the level of social capital. Descriptive statistics for all variables based on the four groups are also presented.

As may be observed from Table 1, the US and most European countries belong to quartile 1 and quartile 2. Among other countries, only Japan and South Korea possess the level of social capital above average of 5.063. Meanwhile, with the exception of few central and east European countries, all developing countries are in quartile 3 and 4. Note also that the carbon emissions per capita increase as we move from countries in quartile 4 to quartile 1. However, variations in CO_2 emissions are largest in quartile 3's countries. GDP per capita, energy consumption and urbanisation also increase from quartile 4 to quartile 1. This provides a rough indication that they may be responsible for higher carbon emissions. Central to our theme, an indication of a non-linear relation between real GDP per capita and carbon emissions per capita can also be casually observed. While the level of average GDP per capita in quartile 3 is almost doubled of that in quartile 4, the corresponding CO_2 emissions are more than doubled. Then, the increase in CO_2 emissions from quartile 3 to quartile 2 is marginal even if real GDP per capita is almost tripled. Likewise, the increase

Table 1
Country list and descriptive statistics.

(a) Countries and levels of social capital

Quartile 1		Quartile 2		Quartile 3		Quartile 4	
Country	SC	Country	SC	Country	SC	Country	SC
Netherlands	8.29	France	6.23	Poland	4.77	Mexico	3.79
Denmark	8.23	Spain	5.95	Trinidad & Tobago	4.67	Moldova	3.68
Australia	8.12	Italy	5.87	Macedonia	4.50	Colombia	3.56
New Zealand	8.06	Cyprus	5.80	Thailand	4.45	Venezuela	3.43
Sweden	8.06	Estonia	5.71	Serbia	4.43	India	3.39
Iceland	7.77	S. Korea	5.70	Argentina	4.38	Iran	3.38
Switzerland	7.75	Malta	5.65	South Africa	4.29	Indonesia	3.33
United States	7.43	Slovenia	5.58	Jordan	4.14	Morocco	3.29
Canada	7.39	Greece	5.57	Brazil	4.04	Belarus	3.18
Austria	7.17	Hungary	5.44	Peru	4.02	Kyrgyz Rep.	3.12
Luxemburg	7.16	Chile	5.17	Ukraine	4.00	Vietnam	3.11
Finland	7.06	Croatia	4.98	Bosnia	3.98	Algeria	3.07
UK	7.05	Lithuania	4.98	Turkey	3.97	Philippines	3.00
Germany	6.98	Slovak Rep.	4.96	Malaysia	3.94	Egypt	2.97
Belgium	6.83	Portugal	4.93	Russia	3.91	China	2.78
Ireland	6.69	Latvia	4.88	Albania	3.87	Bangladesh	2.54
Japan	6.44	Bulgaria	4.77	Romania	3.83	Zimbabwe	1.62
Czech Rep.	6.24						

(b) Descriptive statistics

Variables	All	Quartile 1	Quartile 2	Quartile 3	Quartile 4
SC					
Mean	5.063	7.373	5.422	4.188	3.132
Std. Dev.	1.671	0.630	0.445	0.295	0.500
CO_2					
Mean	6.807	11.317	6.777	6.357	2.511
Std. Dev.	4.933	4.582	2.346	5.356	2.052
GDP					
Mean	11,110.480	28,271.950	10,162.130	3316.717	1681.602
Std. Dev.	12,173.670	9560.240	5814.243	2257.738	1594.833
EC					
Mean	2996.931	5584.734	2813.867	2402.001	1034.900
Std. Dev.	2482.442	2429.999	815.214	2577.611	756.598
OPEN					
Mean	89.405	97.070	100.621	85.261	74.229
Std. Dev.	46.156	61.275	39.093	43.599	34.251
INV					
Mean	22.385	21.468	23.978	20.676	23.470
Std. Dev.	4.385	2.716	3.501	2.911	6.720
URBAN					
Mean	65.548	80.604	69.150	60.232	51.322
Std. Dev.	18.763	8.921	11.676	19.452	19.571

Note: SC = Social Capital; CO_2 = carbon dioxide emissions per capita; GDP = real GDP per capita; EC = energy consumption per capita; OPEN = trade openness; INV = investment; and URBAN = urbanisation.

in CO_2 emissions from quartile 2 to quartile 1 is less than doubled although quartile 1's real GDP is almost three times of quartile's 2 real GDP. As for openness and investment, the quartile 2's countries are most open and have highest investment–GDP ratio.

3. Estimation results

Table 2 contains the results for the baseline specification without and with social capital, i.e. model (1) and model (2), estimated using both first-difference GMM and system GMM estimators. Meanwhile, Table 3 presents the system GMM estimator of the EKC extended to include other controlled variables, namely, trade openness, investment ratio and urbanisation. The specification tests reported in both tables suggest the appropriateness of the GMM estimators. The Sargan test does not reject the over-identification restrictions, suggesting that we have valid instruments. Moreover, the serial correlation test fails to reject the null of no second-order autocorrelation while it rejects the null of no first-order autocorrelation. Accordingly, the residuals of the level equation (before differencing) do not suffer from the autocorrelation problems.

The results from estimating model (1) as given in Table 2 conform to our expectations that CO_2 emissions tend to depend on past emissions and to increase with energy use. The estimated coefficients of the energy consumption, in particular, remain largely similar across estimations (see Tables 2 and 3). They suggest that a 10% increase in energy consumption per capita is related to the increase in expected carbon emissions per capita by roughly 8.5–9.2%. Despite methodological differences, our estimates are close to the ones reported by Atici [24] for Central and Eastern Europe, Acaravci and Ozturk [41] for Europe and Apergis and Payne [17] for Central Asia, but are higher than Lean and Smyth [18] for ASEAN. More specifically, the estimates of the energy consumption coefficients range from 1.08 to 1.53 by Ataci [24], from 0.72 to 1.50 by Acaravci and Ozturk [41] and 0.85 by

Table 2
Baseline results.

	Model 1 (without SC)		Model 2 (with SC)	
	Difference GMM	System GMM	Difference GMM	System GMM
Constant	−9.4998 (0.000)	−8.9419 (0.000)	−10.0629 (0.000)	−10.0024 (0.000)
LCO_{2t-1}	0.0605 (0.120)	0.2760 (0.000)	0.0898 (0.020)	0.3187 (0.000)
LGDP	1.1527 (0.000)	0.9519 (0.000)	1.7870 (0.000)	1.4394 (0.000)
$LGDP^2$	−0.0708 (0.000)	−0.0655 (0.000)	−0.1201 (0.000)	−0.1056 (0.000)
LEC	0.8437 (0.000)	0.9005 (0.000)	0.8491 (0.000)	0.8960 (0.000)
$LGDP \times SC$	–	–	−0.1026 (0.226)	−0.0156 (0.012)
$LGDP^2 \times SC$	–	–	0.0080 (0.072)	0.0053 (0.022)
Sargan test: *p*-value	0.441	0.651	0.387	0.381
AR1: *p*-value	0.078	0.007	0.048	0.003
AR2: *p*-value	0.159	0.431	0.227	0.569

Note: numbers in parentheses are *p*-values.

Table 3
System GMM estimation with additional controlled variables.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Constant	−9.4917 (0.000)	−10.059 (0.000)	−9.5431 (0.000)	−9.7929 (0.000)	−9.1476 (0.000)	−9.6330 (0.000)	−9.2761 (0.000)
LCO_{2t-1}	0.3264 (0.000)	0.3036 (0.000)	0.3136 (0.000)	0.3080 (0.000)	0.3183 (0.000)	0.3119 (0.000)	0.3146 (0.000)
LGDP	1.2561 (0.000)	1.4761 (0.000)	1.1381 (0.000)	1.3568 (0.000)	1.0186 (0.000)	1.1782 (0.000)	1.0666 (0.000)
$LGDP^2$	−0.0898 (0.000)	−0.1069 (0.000)	−0.0888 (0.000)	−0.0959 (0.000)	−0.0779 (0.000)	−0.0907 (0.000)	−0.0802 (0.000)
LEC	0.9095 (0.000)	0.9066 (0.000)	0.9161 (0.000)	0.9180 (0.000)	0.9236 (0.000)	0.9172 (0.000)	0.9227 (0.000)
$LGDP \times SC$	−0.0405 (0.048)	−0.0566 (0.007)	−0.0511 (0.011)	−0.0481 (0.027)	−0.0426 (0.034)	−0.0525 (0.009)	−0.0440 (0.031)
$LGDP^2 \times SC$	0.0037 (0.106)	0.0056 (0.016)	0.0051 (0.021)	0.0044 (0.073)	0.0039 (0.079)	0.0052 (0.020)	0.0040 (0.079)
LOPEN	−0.0239 (0.142)	–	–	−0.0081 (0.670)	−0.0183 (0.289)	–	−0.0151 (0.396)
LINV	–	−0.0446 (0.000)	–	−0.0477 (0.000)	–	−0.0149 (0.027)	−0.0157 (0.015)
LURBAN	–	–	0.1847 (0.082)	–	0.1659 (0.104)	0.1750 (0.119)	0.1587 (0.143)
Sargan test: *p*-value	0.458	0.452	0.511	0.563	0.544	0.501	0.540
AR1: *p*-value	0.002	0.006	0.005	0.005	0.004	0.005	0.004
AR2: *p*-value	0.541	0.487	0.560	0.468	0.533	0.549	0.521

Note: numbers in parentheses are *p*-values.

Apergis and Payne [17]. Meanwhile, Lean and Smyth [16] estimate the coefficient of energy consumption to be roughly 0.50 for the ASEAN countries.

Likewise, we obtain empirical support for the presence of the EKC as indicated by the significantly positive coefficient of real GDP per capita and significantly negative coefficient of real GDP per capita squared. Based on model (1), the income threshold point is between USD1431 (system GMM) and USD3431 (first-difference GMM). These estimates are within those of Atici [24] for central and eastern Europe. In his analysis of four central and eastern European countries (Bulgaria, Hungary, Romania, and Turkey), he finds the income threshold point to be USD2077–USD3156. As he notes, this estimate is substantially lower than those by Schmalensee et al. [42] for the US (USD10,000) and by Cole et al. [43] for OECD countries (USD25,000). Perhaps, given our sample, there may be relatively high awareness of environmental degradation problem that triggers the need for better environment during the recent periods.

We next estimate the EKC with the presence of social capital, i.e. model 2, to address our central thesis that social capital can be relevant. The results are also presented in Table 2. From the system GMM estimation, the coefficient of real GDP is $1.4394-(0.0156 \times SC_i)$. Meanwhile, the coefficient estimate of real GDP squared is $-0.1056+(0.0053 \times SC_i)$. These results suggest several noteworthy points. First, they do not overturn the validity of the EKC. The coefficient of real GDP remains positive while that of real GDP squared negative regardless of the level of social capital. Second, as reflected by the significance of the two interactive terms at conventional levels of significance, the results suggest the importance of social capital in influencing the EKC. Third, the significant negative coefficient of the interaction between SC and real GDP suggests that the environmental costs of economic development are lower for a country with higher level of social capital, given the level of development and energy use. In other words, the EKC shifts downward as the social capital increases. And finally, the positive coefficient of the interaction between real GDP squared and social capital suggests that the threshold point can be lower or higher for a country with higher level of social capital depending on the relative reduction in the coefficient of real GDP vis-à-vis the reduction in the coefficient of real GDP squared.

To shed further lights on these, we simulate the environmental Kuznets curves for various levels of social capital. It is important to point out that, in evaluating the impact of social capital on the EKC, the initial CO_2 emissions and energy use must be held constant. Accordingly, for the purpose of simulation, we set the initial carbon emissions per capita to 0.276 and hold the energy use per capita constant at 166.35 kg of oil equivalent. These figures correspond to the average figures of Bangladesh.[3] Then, we graph the curves for three alternative levels of social capitals. These are (i) $SC=2.54$, (ii) $SC=5.06$, and (iii) $SC=8.29$, which correspond respectively to the case of Bangladesh, average social capital, and maximum social capital in the sample. In essence, in this simulation exercise, we ask what the EKC for the Bangladesh would be if its social capital improves to 5.06 and 8.29.

The simulated EKCs are presented in Fig. 1, where the vertical axis is carbon emissions per capita (in metric tons) while the

[3] It should be noted that using other initial CO_2 emissions and energy consumption will not in any way affect the conclusions made. Different initial CO_2 emissions and energy consumptions will only affect the height of the EKC but will not change the relations between real GDP and emissions and the role of social capital in the relations..

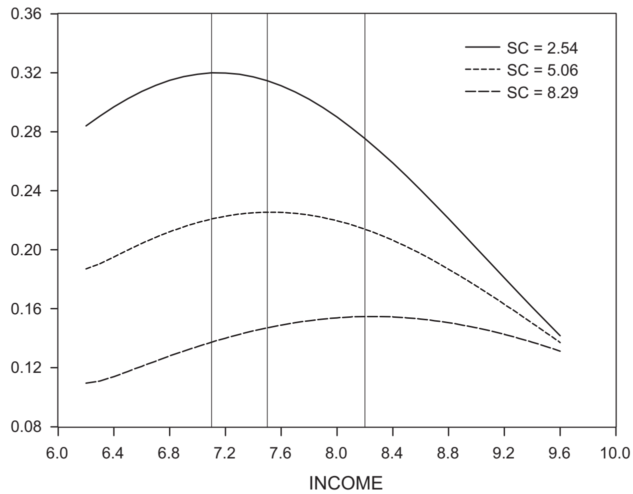

Fig. 1. Simulated EKC.

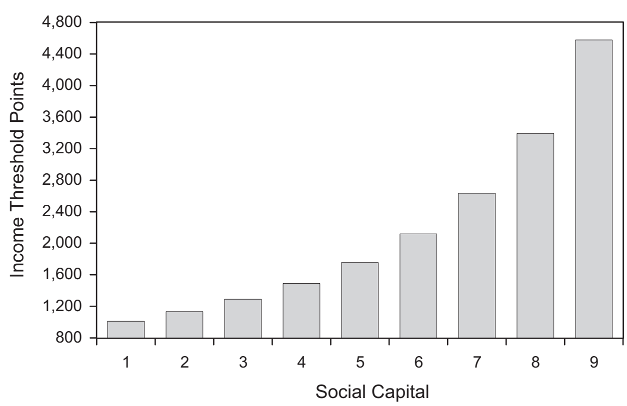

Fig. 2. Social capital and income threshold points.

horizontal axis is GDP per capita (in natural logarithm). The vertical lines represent the income threshold points for the three cases. The plots clearly indicate that the EKC shifts downwards as the social capital increases. Moreover, the environmental benefits (or reduced environmental degradation) of social capitals are larger at lower levels of income. As an example, at the income level of 6.2 (per capita GDP=USD493) and holding other factors constant, the expected carbon emissions per capita drop from 0.284 to 0.187 and to 0.109 as social capital increases from 2.54 to 5.06 and to 8.29. Meanwhile, at the income level of 7.5 (per capita GDP=USD1808), the corresponding figures of carbon emissions are 0.315, 0.225 and 0.147.

From the figures, we also find the income threshold points to be higher for a higher social capital. Complementing Fig. 1, we plot in Fig. 2 the income threshold points for various levels of social capital based on Eq. (3). All else equal, the income threshold points for countries with social capitals equal to 1, 5 and 9 are respectively USD1011, USD1756 and USD4578. In comparison with [40,41], our estimates remain substantially lower. Since we focus on the recent period, it is conceivable that the increasing awareness and willingness to deal with environmental problems may account for our lower estimates as noted earlier.[4] The finding that the income threshold point is higher for a higher social capital country may seem perplexing. Reasonably, there may be an environmental trigger point beyond which the environmental problem becomes a major concern and is viewed to post hazards to health and well-being. For a higher social capital country, this trigger point may come at a higher level of income given that the incremental environmental costs of economic development are significantly less. While this explanation is tentative, we believe that it is not entirely implausible.

As a further analysis, we perform a robustness check by incorporating trade openness, investment ratio and urbanisation in the EKC specification. The results are given in Table 3. The validity of the EKC is further substantiated. The results soundly support our earlier conclusion that the degradation of environment tends to be less for a country with higher social capital as the country develops. Likewise, the income threshold point beyond which CO_2 emissions decline tends to be higher for the country with better social capital. These robust findings lend credence to our thesis that social institutions shaped by trust, norms, networks and social structure are an important catalyst in addressing the threat emanating from the pursuit of economic progress to the environments. Accordingly, in addition to the widely recommended use of renewable energy and investment in environmentally friendly technology, building up reservoir of social capital can be a complementary mean for solving the present environmental problems [12].

Finally, as side results, we find the coefficient of trade openness to be indistinguishable from zero. This finding may be due to the presence of contradicting scale, technique and composition effects as noted by Antweiler et al. [25]. Likewise, urbanisation has insignificant relation with CO_2 emissions. By contrast, the increase in the investment ratio is significantly and negatively associated with emissions. This seems to suggest that investment is embedded with improved technology that emits less pollution.

4. Conclusion

The present paper examines the role of social capital in the income–environment relations for CO_2 emissions for a panel of 69 developed and developing countries. More specifically, the paper empirically assesses whether the environmental costs of economic development decrease as the level of social capital rises and whether the income threshold point is influenced by social capital using panel GMM estimators. Our results provide supportive evidence for the validity of EKC in the sample countries, as reflected by the positive coefficient of per capita real GDP and negative coefficient of its squared value. Then, by interacting social capital with both real GDP per capita and real GDP per capita squared, we observe the significant coefficients of both interactive terms. This means that social capital does play a role in the shape of the EKC. We note that social capital tends to reduce the environmental costs of economic progress by shifting the EKC downwards at any given level of income, after holding other determining factors of carbon emissions constant. In addition, the reduction in carbon emissions tends to be larger at the early stage of economic development. Interestingly, we also find evidence suggesting higher income threshold point for a higher social capital country. These conclusions have added credence as they are robust to the inclusion of various controlled variables in the EKC specification.

These results have several important implications. First, they strengthen the case for heterogeneous environmental Kuznets curves across countries. Accordingly, any study that treats the EKC to be homogenous may yield misleading conclusion. Second, while we offer evidence that social capital is a potential factor underlying this heterogeneity, the benefits of social capital is more apparent at early stages of economic development. As generally

[4] Apart from the time period, estimation methods and country samples may contribute to the differences. While these seem to be standard reasons underlying differences in empirical findings across studies, they suggest that we need to be overly cautious in comparing the quantitative estimates across studies.

noted in the literature, formal institutions like rules and regulations and enforcement mechanisms are generally weak in poor or developing countries. Accordingly, as countries are striving towards higher growth, informal institutions like trust and norms can substitute the formal rules and regulations in ameliorating the global environment problems. Finally, in the literature, various measures have been suggested to ameliorate the environmental implications of economic development. Among them include the shift in composition of energy sources from fossil fuels to renewable energy sources and the use of more environmentally friendly technology. Our analysis suggests further that, as a complementary measure, focusing on building up social capital might be equivalently important in reducing emission impacts of economic development. In this regards, further research may be needed to focus on determinants of social capital investment with the suggestions by Illingworth [12] to be perhaps the starting point.

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